Chandra ACIS-I3 Gain Droop

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Chandra ACIS Response

Components:

- `detgain` - epoch 1 detector gain (energy, chipy, chipx)
- `p2_resp` - epoch 1 response width (energy, chipy, chipx)
- `detgain`, `p2_resp` are tightly coupled; determined by iteration

Time dependent gain correction:

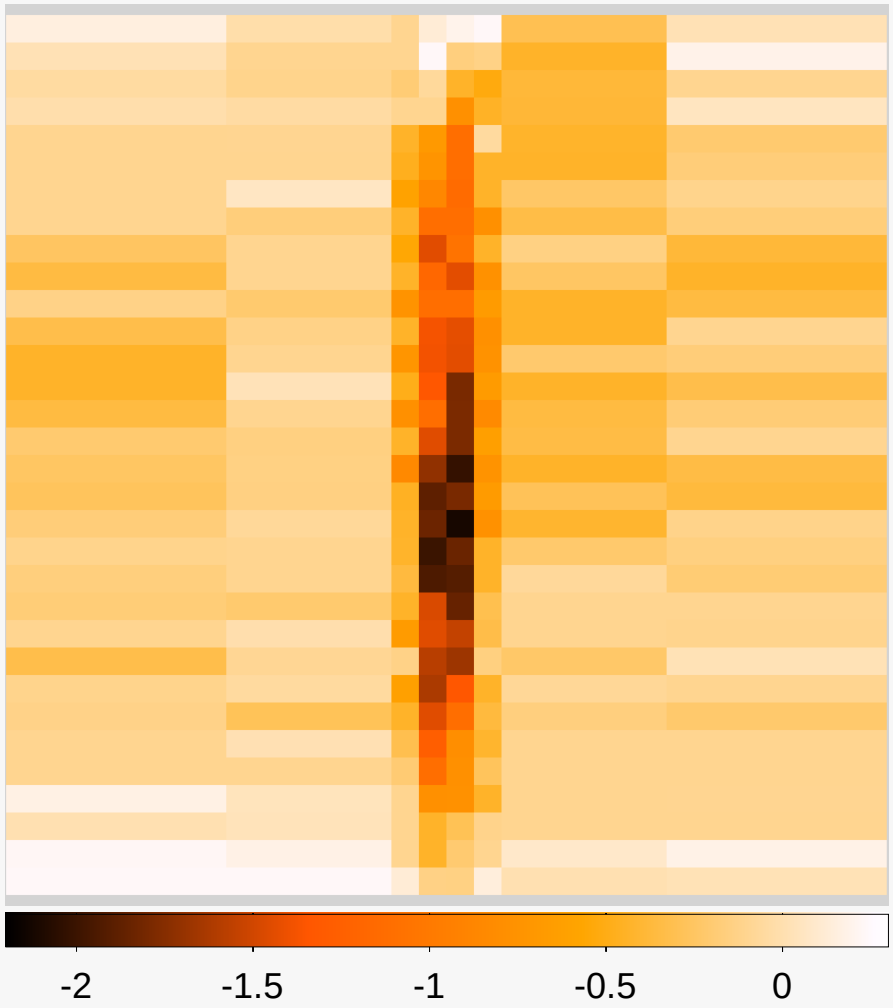
- builds on `detgain`
  - any defects in `detgain` propagate to later gains

ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

- FI chip gain depressed adjacent to node 1/2 boundary
  - (chipx=512/513 $\pm \sim 32$)
  - decrement $\sim 10 - 20\,\mathrm{eV}$
- more important at low-E.
  For example: $\Delta E = 10\,\mathrm{eV}$
  - 1.5 keV: 0.7%
  - 0.6 keV: 1.7%
- Calibration aim: $\sim$ 0.3%
- Main ECS lines:
  - 1.5 keV (Al-Kα)
  - 4.5 keV (Ti-Kα)
  - 5.9 keV (Mn-Kα)

ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Epoch 1, -120.19 C to -119.19 C
ACIS-I3, Al-Kα (1.486 keV)



ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Constraining low-*E* gain:

- E0102? very sparse spatial coverage 2000/2001 (even sparser later); OK for “sanity checks”
- ECS Mn-L/Fe-L/F-K complex $\sim 0.64\,\mathrm{keV}$
  - well isolated, but *much* weaker than main ECS lines
- Approach: Fit:
  - $\sim$ 0.64 keV: Mn-L/Fe-L/F-K complex
  - 1.5 keV: Al-Kα
  - 4.5 keV: Ti-Kα
  - 5.9 keV: Mn-Kα
  - 6.5 keV: Mn-Kβ

ACIS-I3 Mid-Chip "gain droop" (w/ CALDB gain, resp)

Constraining low-E gain:
Current CALDB:

- Δ`chipx` = 256
- Δ`chipy` = 32

Revised `detgain`, `p2_resp`

- Al-Kα, Ti-Kα, Mn-Kα, Mn-Kβ
  - Δ`chipx` = 256, 192, 32, 32, 32, 32, 192, 256
  - Δ`chipy` = 32
- Mn-L/Fe-L/F-K: coarse tiling:
  - Δ`chipx` = 448, 128, 448
  - Δ`chipy` = 256
  - map Δ`chipx`, Δ`chipy` onto finer grid

Mitigation Approach

- Refit ECS Epoch 1 data for I3
- Mn-L/Fe-L/F-Kα, Al-Kα, Ti-Kα, Mn-Kα, Mn-Kβ
  - evaluate $100 \times \Delta E/E$
  - interpolate onto reduced `detgain` E-grid
  - piecewise linear extrapolation to 0 to get full `detgain` energy grid
  - revised energy: $E + \Delta E$
  - Interpolate `detgain PHA`
  - construct new `detgain`
- test new `detgain` against data
  - Remake RMFs
  - Refit, determine new gain shifts
  - use new ΔE to derive a better modificatoin
- Generate new CALDB products for `p2_resp`, `detgain`, `osip`. (These are always a matched set.)

ACIS-I3 Mid-Chip “gain droop” (w/ CALDB gain, resp)

Merging the results:

- Chebyshev smooth vs. `chipy`
- Mn-L/Fe-L/F-K: coarse tiling:
  - interpolate Δ`chipy` = 256 tiles onto Δ`chipy` = 32 tiling
  - Chebyshev smooth vs. `chipy`

`detgain` energy grid: 30 energies (12 below, 4 above ECS):

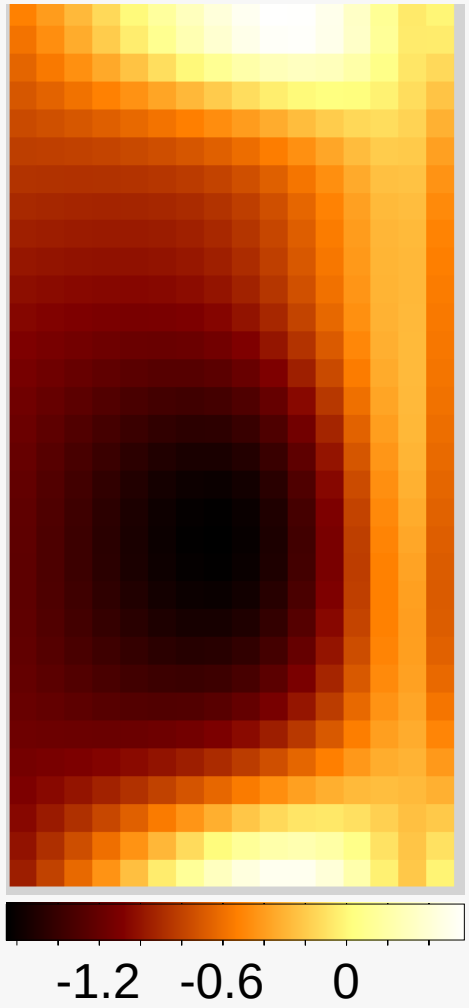
0.100, 0.113, 0.139, 0.164, 0.194, 0.228, 0.269, 0.318, 0.375, 0.442, 0.521, 0.615, 0.725, 0.855, 1.01, 1.20, 1.40, 1.66, 1.20, 2,30, 2.72, 3.20, 3.78, 4.46, 5.26, 6.20, 7.31, 8.63, 10.17, 12.00

Interpolate in energy:

- map five ECS energies onto overlapping (16) `detgain` energies
- linearly taper onto remaining (lower and higher) `detgain` grid
- Result: x,y,energy tiles: $8 \times 32 \times 30$

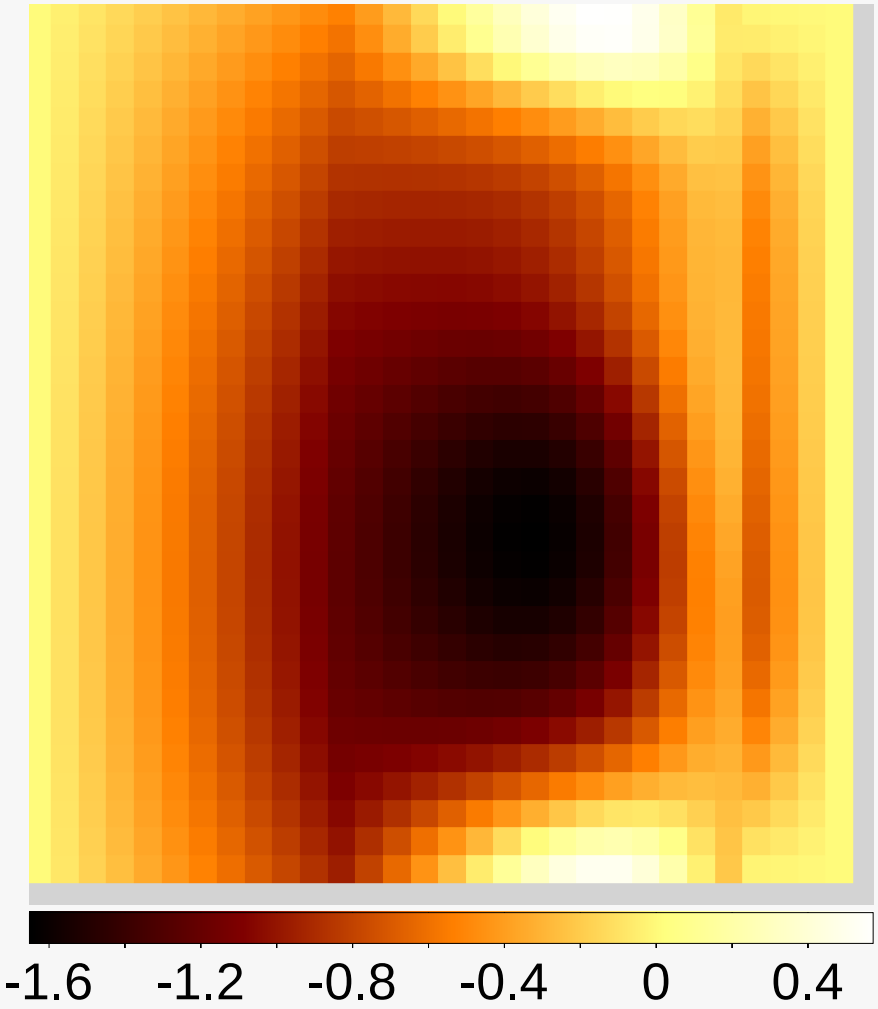
ACIS-I3 100×ΔE/E chipy vs. detgain E

chipy vs. E, chipx = 481:512
(partial detgain grid)



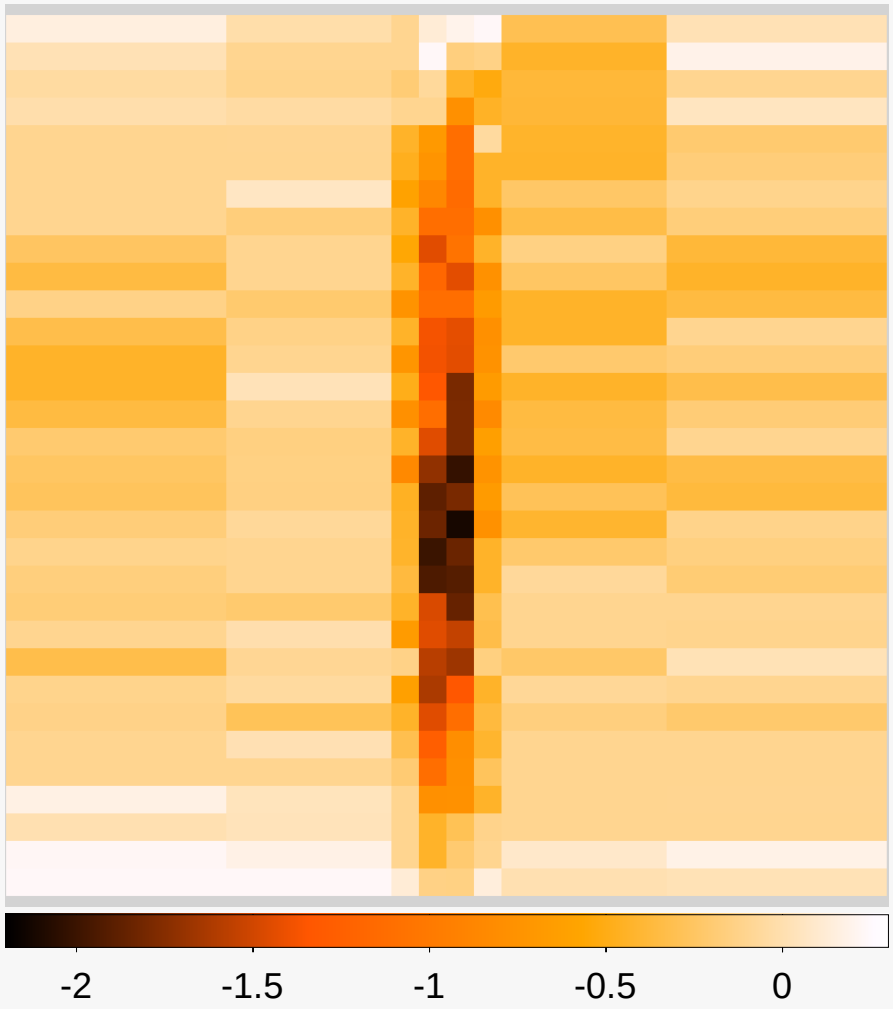
ACIS-I3 100×ΔE/E chipy vs. detgain E

chipy vs. E, chipx = 481:512
Full detgain grid)



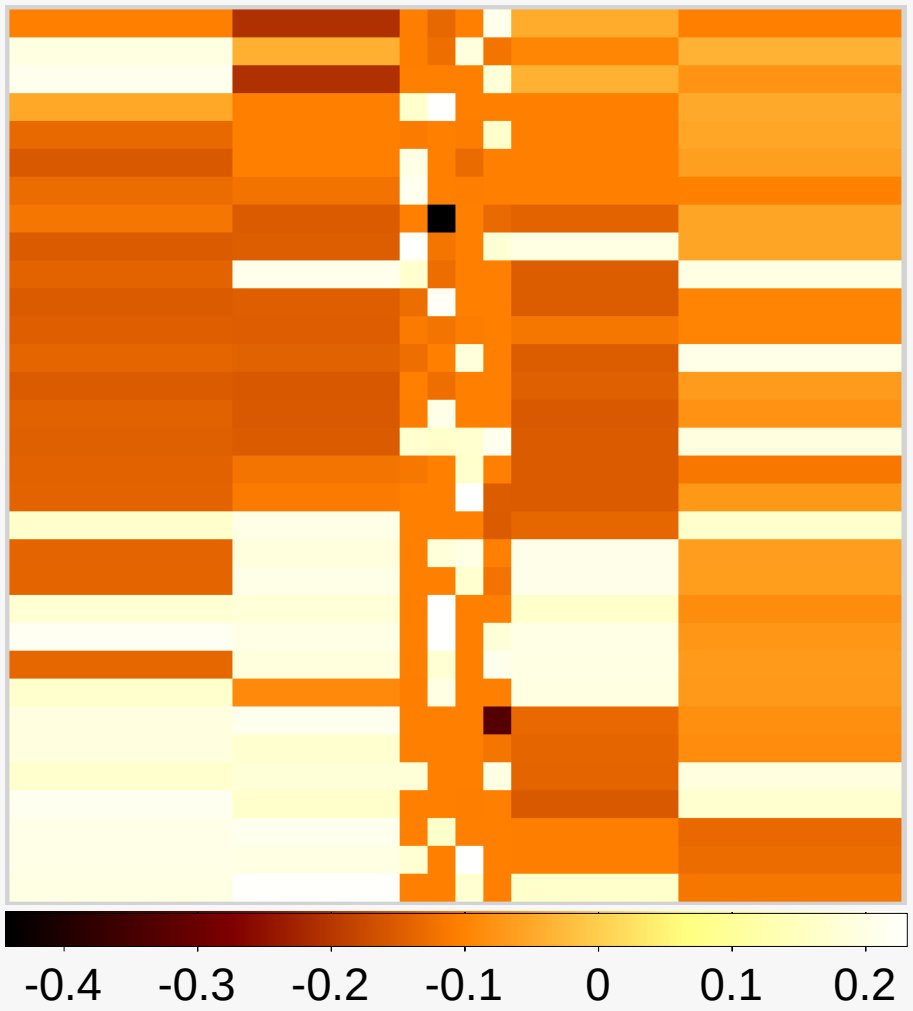
ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
1.49 keV [original]



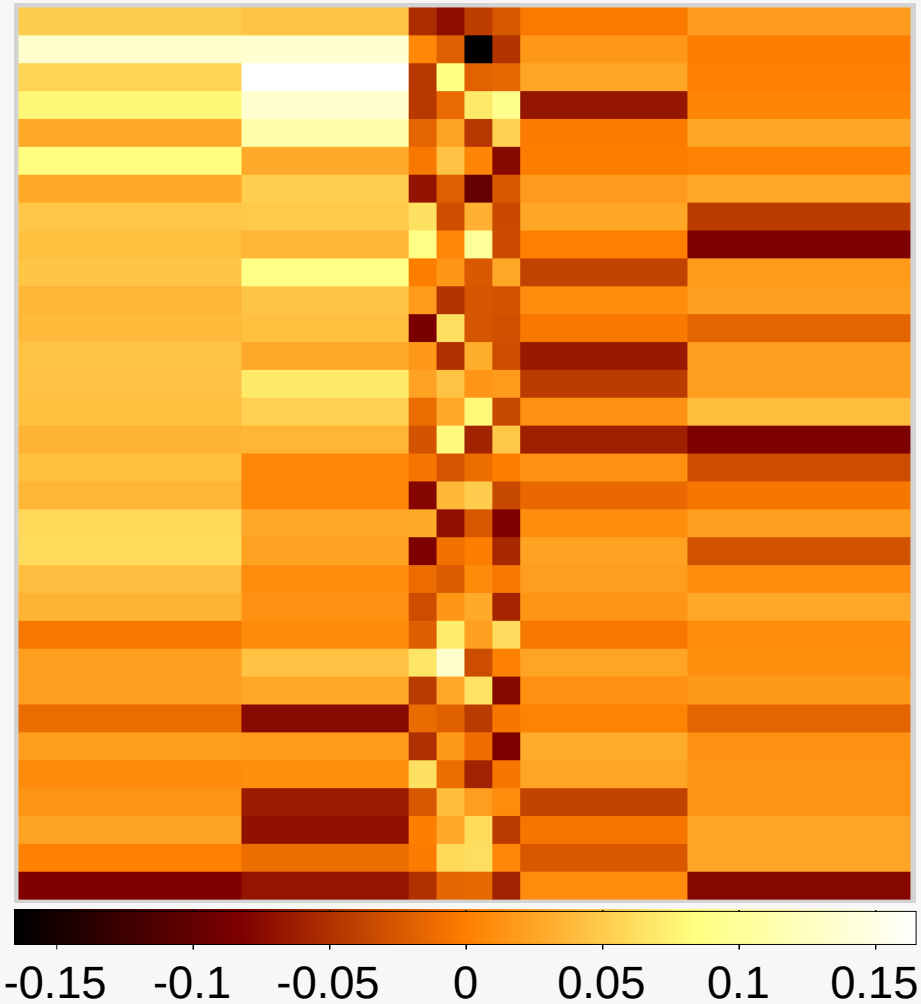
ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
1.49 keV



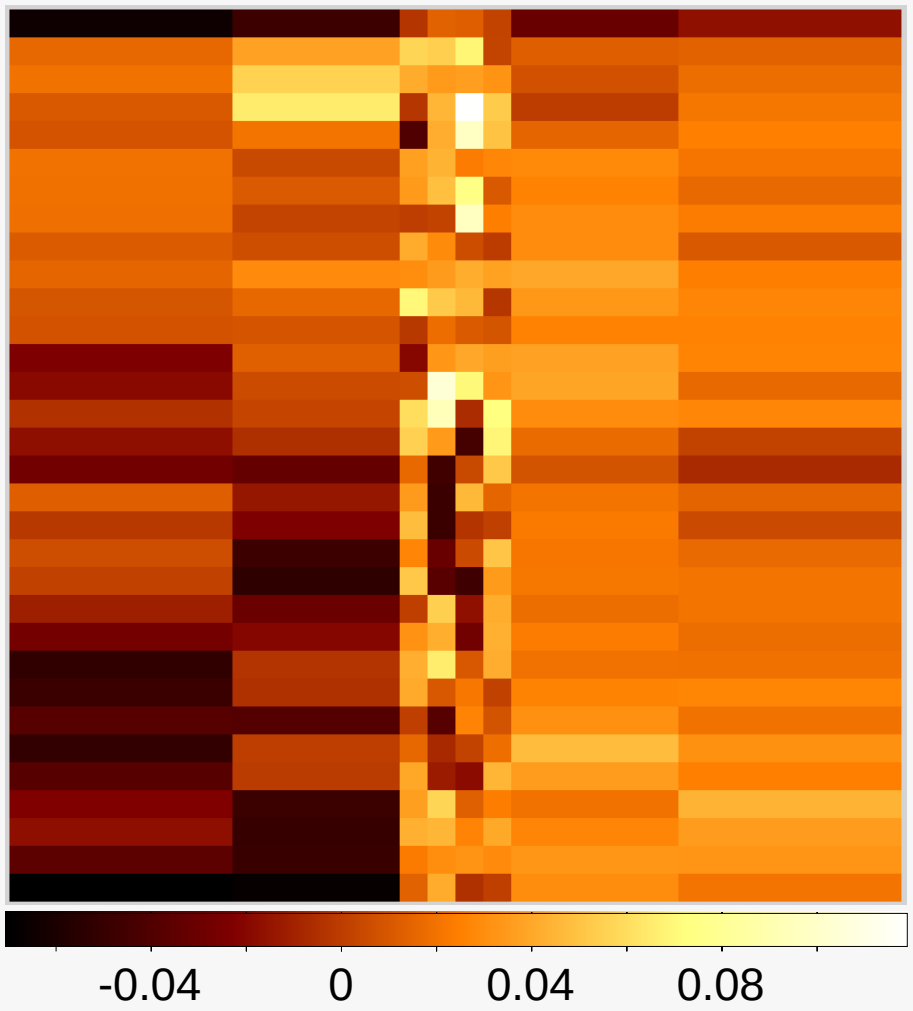
ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
4.51 keV



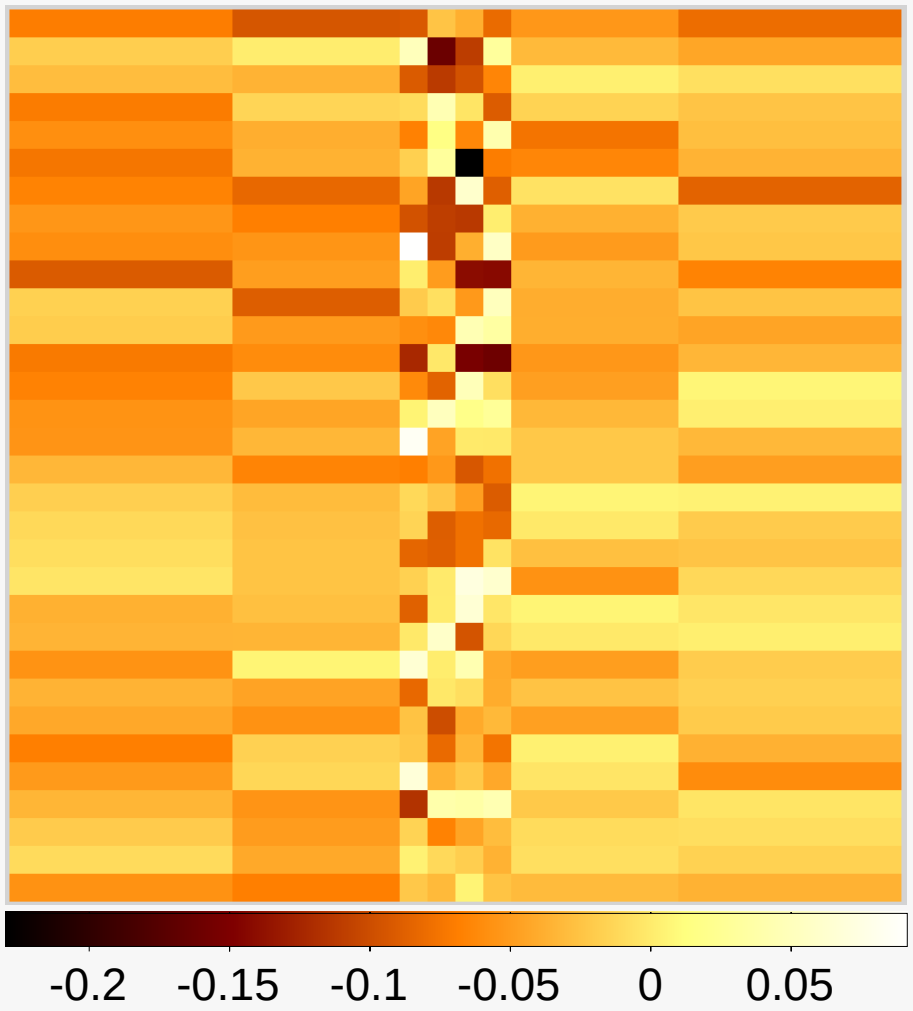
ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
5.90 keV



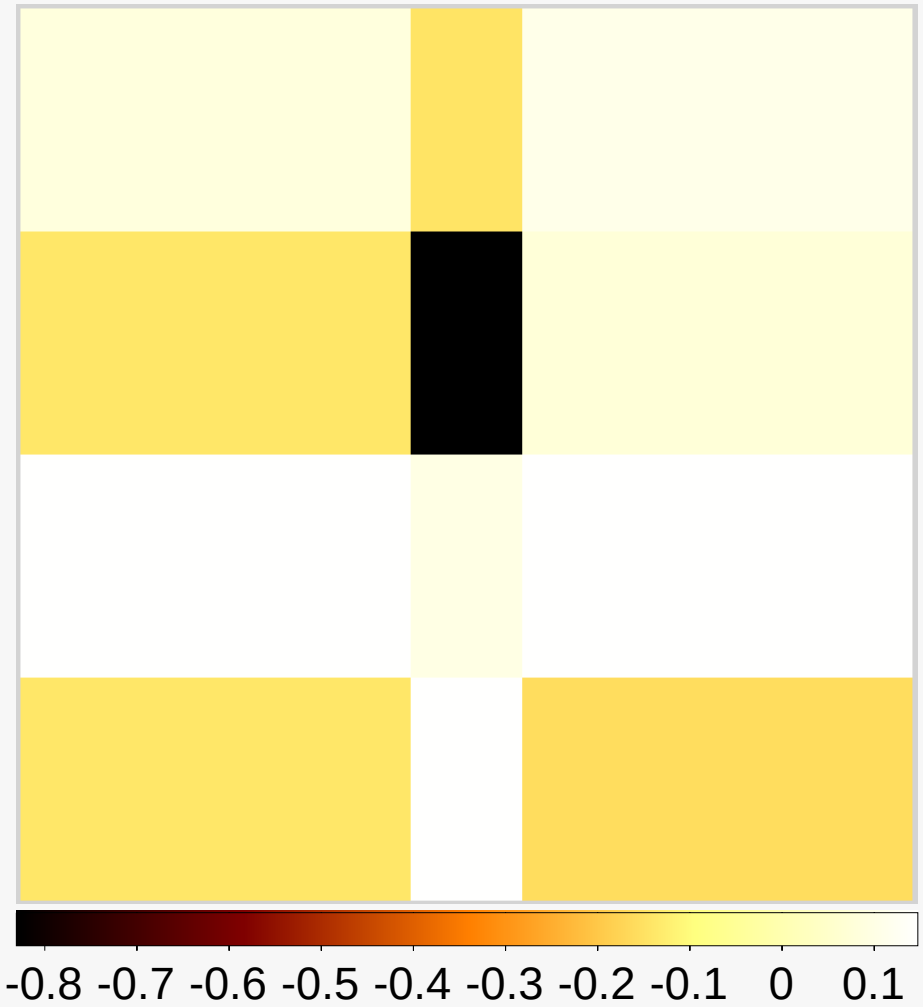
ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
6.49 keV



ACIS-I3 Mid-Chip “gain droop” (w/ trial gain, resp)

`chipy` **vs.** `chipx`
0.64 keV (coarse grid)



Summary

Summary:

- use fits to five ECS energies: $100 \times \Delta E/E$
  lowest energy on coarser `chipy`, `chipx` grid
- Chebyshev smooth (interpolate) ΔE onto partial `detgain` grid
- extrapolate onto full `detgain` grid
- corrected energy: $E + \Delta E$
- generate new `detgain`
- refit ECS data; adjust gain modification and retry
- "sanity" check against (sparse) E0102 data

- extend treatment to I0, I1, I2, S2
- release new `detgain` for more extended testing
- CALDB release: new `detgain`, `p2_resp`, `osip`